Solid Earth

ES-3 The student will demonstrate an understanding of the internal and external dynamics of solid Earth.

Key Concepts for ES-3:
Origin-Formation of Earth's Systems: gravitational force, heat production; nebular theory
Earth's Layers: core – inner & outer; mantle – lithosphere, asthenosphere, crust
Theory of Plate Tectonics: convection currents; plate boundaries; scientific evidence
Crustal changes: earthquake activity; volcanic eruptions; mountain building
Geologic processes: weathering, erosion, deposition, glaciation
Rock Cycle: divisions of the rock cycle; processes that form types of rocks
Mineral & Rock classification: properties of mineral & rocks;
Ores: formation
Fossil fuels: formation – coal, petroleum, natural gas; environmental impact

ES-3.1 Summarize the theories and evidence of the origin and formation of Earth's systems by using the concepts of gravitational force and heat production.
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: Students have not been introduced to the concepts in this indicator in any previous grade.

It is essential for students to know that according to the *nebular theory* (gravitational condensation theory), Earth was formed as a planet in the solar system from material in the solar nebula that condensed and compacted due to gravitation force.

- Shortly after Earth formed, the decay of radioactive elements and the heat released by colliding particles produced some melting of the rocky material that made up Earth.
- The denser elements, mainly iron and nickel, sank due to gravity to Earth's center, while the lighter, rocky components floated outward toward the surface. This sorting of material by density is believed to be continuing on a smaller scale even today.
- Gaseous materials were allowed to escape from Earth's interior. By this process an atmosphere gradually formed, composed chiefly of gases expelled from within the planet.

Other theories include the planetesimal theory and the tidal theory.

Earth's systems are today powered by energy from the Sun and also from Earth's internal heat. After the formation of the atmosphere and hydrosphere the Sun's energy drives the systems in the atmosphere, hydrosphere, and at Earth's surface. Heat remaining from when Earth formed and that is continuously generated by the decay of radioactive elements, powers the internal processes that produce volcanoes, earthquakes, and mountains.

It is not essential for students to know the details of other theories that do not involve gravitational force and heat production.

Assessment Guidelines:
The objective of this indicator is to *summarize* major points about the formation of Earth; therefore, the primary focus of assessment should be to generalize major points about the nebular theory as it relates to gravitational force and heat production.
In addition to *summarize* appropriate assessments may require students to:

- *compare* the formation of Earth based on various theories;
- *sequence* the events in the formation of Earth; or
- *compare* material that makes up the core with that found in the crust.